Modelling of Magnum-PSI with SOLPS-ITER and B2.5-Eunomia

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Magnum-PSI

Plasma Linear Device Magnum-PSI

- The plasma linear device Magnum-PSI was developed to generated plasma with similar conditions to those expected to be reached at ITER.
- Different targets are exposed to a controlled plasma beam.
- Pressure maintained constant at each chamber.
- All chambers need to be modeled to properly reproduce the plasma and neutral dynamics.

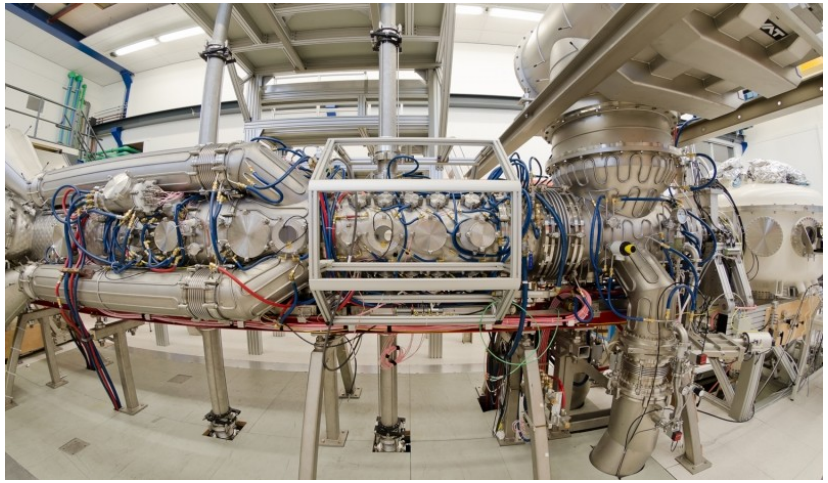

Fig. 1: The plasma Linear Device Magnum-PSI.

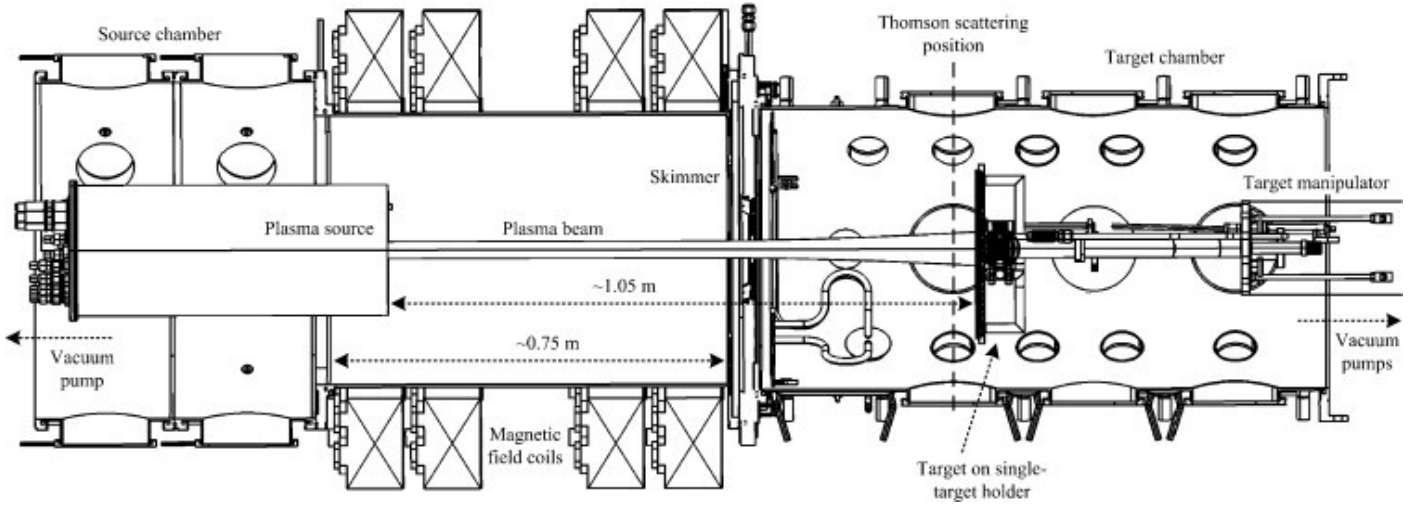

Fig. 2: Section of Magnum-PSI.

Current work with B2.5-Enunomia

Neutral module Eunomia

- Eunomia is a neutral gas module (similar to Eirene) that was developed at DIFFER to be used specific in plasma linear devices (specifically Pilot-PSI and Magnum-PSI).
- It is coupled with B2.5 the same ways as Eirene in SOLPS-ITER.
- Some process, as surface interaction and ion-neutral collisions, are implemented differently as in Eirene.
- Regarding Magnum-PSI simulations, we are switching from B2.5-Eunomia to SOLPS-ITER in the near future.

Comparison with TS data

- Currently, some projects are being developed at DIFFER to simulate Magnum-PSI with B2.5-Eunomia.
- TS data at the plasma source is taken as an input parameter for B2.5.
- TS at the target is used to compare with results from simulations.
- Some adjustment of transport coefficients in B2.5 are required to properly match experimental data.
- However, B2.5-Eunomia is capable of simulating a wide range of plasma parameters in Magnum-PSI.

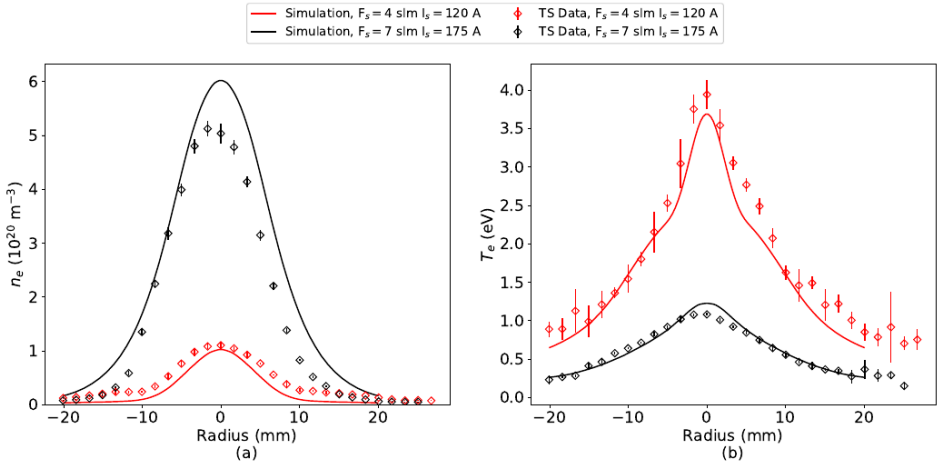

Fig. 3: Comparison of density and temperature at the target for a case of low (red) and high (black) plasma density. Figure taken from [1].

[1] R. Chandra et. al. *Quantitative comparison of Magnum-PSI detachment experiments with B2.5-Eunomia simulations*, Under Revision.

Progress with SOLPS-ITER

Porting Pressure Feedback Loop

- To properly model Magnum-PSI, a Pressure Feedback Loop implemented in Eunomia has been ported in Eirene.
- This loop modifies the reflection coefficient of a wall (RECYCT in Eirene) to match a pressure in the Eirene grid to a reference pressure.
- All input is user defined.
- Three loops are used to simulate the three pumps in Magnum-PSI (one to maintain the pressure in each chamber).
- Low relative error between the pressure and the cell and the reference value.

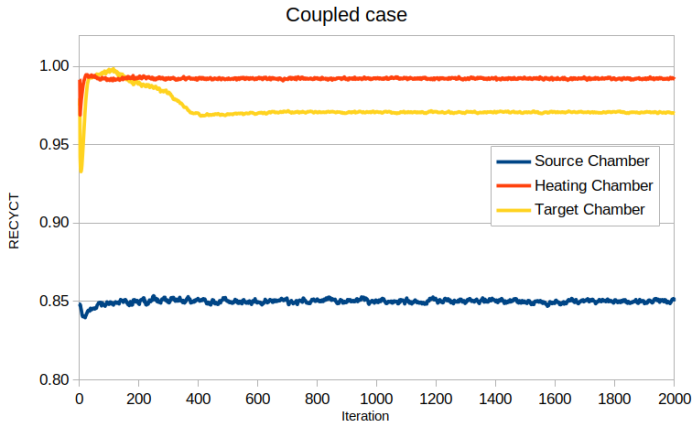

Fig 4. Evolution of RECYCT parameter for 3 PFL.

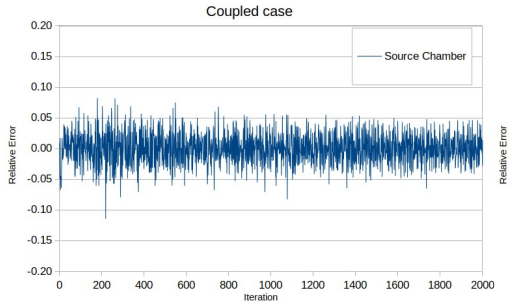

Fig 5. Rel. Error in Source Chamber.

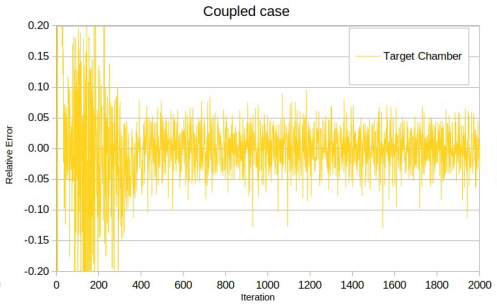

Fig 6. Rel. Error in Target Chamber.

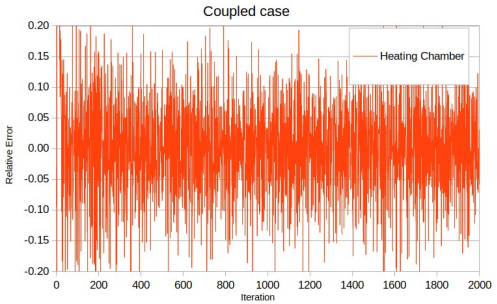

Fig 7. Rel. Error in Heating Chamber.

User defined wall model

- To match Eunomia vessel wall models, an user defined model has been developed to Eirene.
- This model thermally reflects all incident particles.
- For atomic H, a 90% is reflected as thermal H and a 10% is recombined as thermal H_2.
- This model is only used for comparison with Eunomia, as the general fast-thermal reflection model in Eirene will be employed for the next cases.

Systematic comparison of Eirene and Eunomia

- As Eirene and Eunomia have different implementation of similar physical processes, it is necessary to analyze each process individually to properly study these differences.
- This lead to differences in sources to B2.5, even when results are similar.
- Important differences in p + H_2 elastic collisions profiles, even with frozen plasma background.

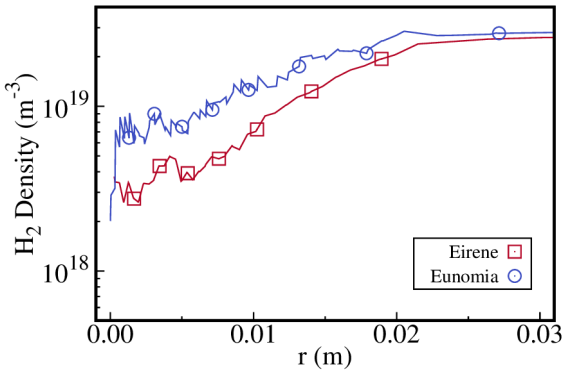

Fig 8. Density profile near the target when p + H_2 is active.

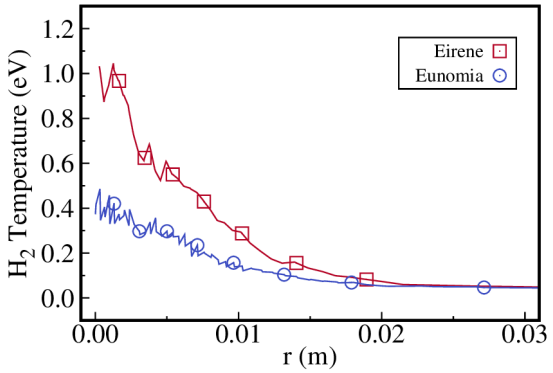

Fig 9. Temperature profile near the target when p + H_2 is active.

Future work

Full Magnum-PSI case in SOLPS-ITER

- As Eirene and Eunomia comparison finishes, we are starting to work in a case that uses the full physics of Eirene to model Magnum-PSI.
- As input for simulations are TS measurements at source, these are required.
- TS measurements at the same plasma parameters are used for validation of simulations.
- Results will be compared with experimental TS data and with Eunomia results.
- This will include: using TRIM model, Eirene wall reflection model, recycling of plasma into neutrals for $r > r_{beam}$.

Finite Element Wall model

- Coupling of Eirene and B2.5 with a finite element to describe wall model.
- This model will self-consistently compute wall temperature, sputtering, gassing…
- First model based on ITER monoblock.
- Capability to better study heat transfer to the target and compare with Magnum-PSI experimental data.

Thank you for your attention

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